HANDFAST POINT TO BALLARD POINT

OS Grid Reference: SZ043824–SZ048813

Introduction

The Handfast Point to Ballard Point GCR site, near Studland, Dorset (Figures3.53 and 3.54), is perhaps the most inaccessible and inhospitable Upper Cretaceous section of all the Upper Cretaceous GCR sites. As Rowe (1901, p. 37) indicated, however, it is also the most important section in the Upper Campanian *Belemnitella mucronata* Zone, but this can only be worked by boat.

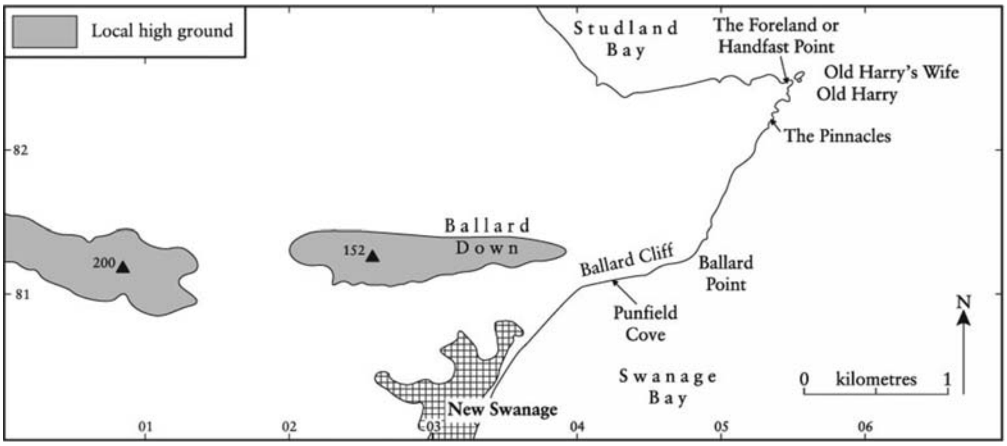

Figure 3.53: The Handfast Point to Ballard Point Upper Cretaceous GCR site, Swanage, Dorset.

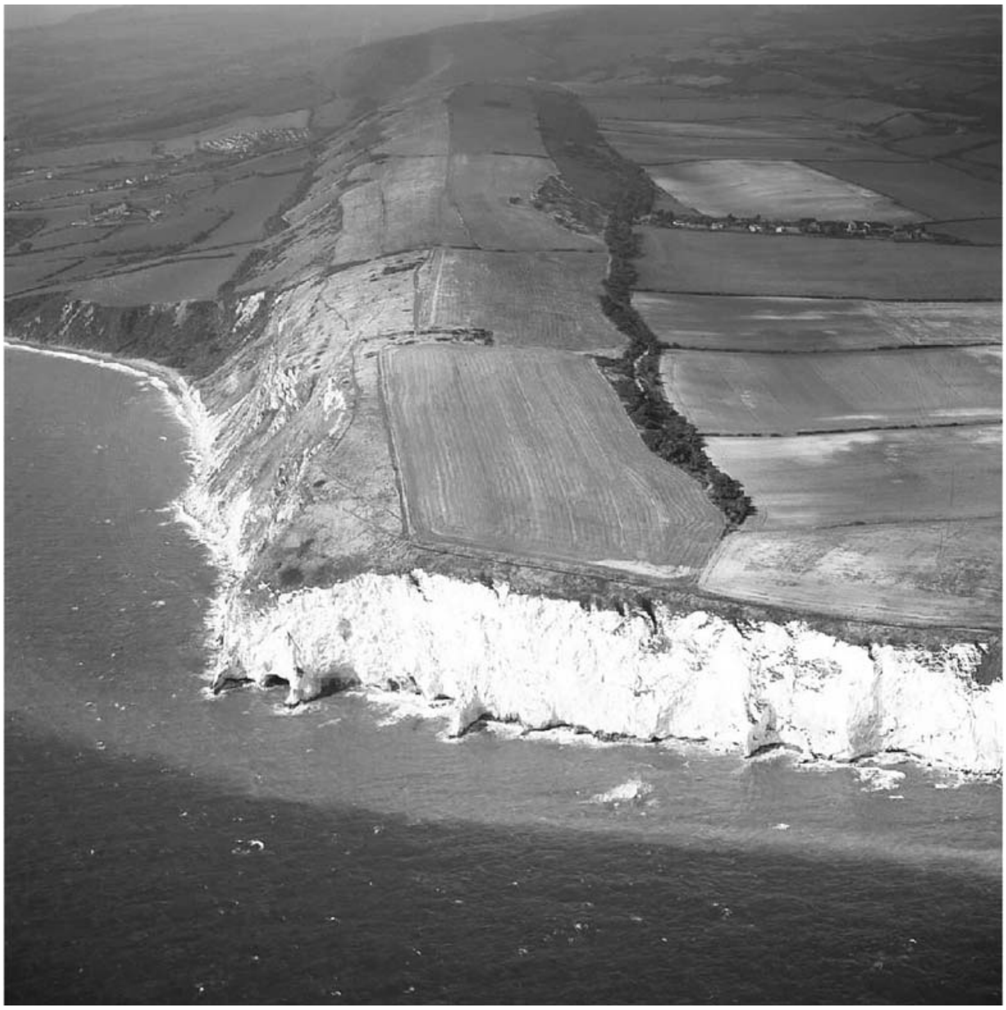

Figure 3.54: The two ends of the Handfast Point to Ballard Point GCR site. (a) The southern end at Ballard Head, looking south-west. (b) The northern end at Handfast Point – Handfast Point and Old Harry sea stack looking south-west. (Photos: Cambridge University Collection of Aerial Photography; copyright reserved.)

There are three parts to this coastal cliff section (Figure 3.53), which has been formed by the sea breaking through a narrow Chalk ridge that once continued eastwards to the Needles, Isle of Wight. The first part extends from Swanage Bay (Punfield Cove) to Ballard Point. It exposes a section from the contact of the Chalk Group on the Lower Cretaceous (Upper Greensand) up to the top of the lower Lewes Nodular Chalk Formation. The Grey Chalk Subgroup (Zig Zag Chalk Formation) rests here on a glauconitic Basement Bed containing phosphatized Middle Cenomanian ammonites. The upper Lewes Nodular Chalk forms the Headland and was estimated by Rowe to be about 42 ft (13 m) thick. The second part, from this point northwards to Handfast Point and Old Harry Rocks, constitutes the GCR site *sensu stricto*, and contains the Ballard Fault (Figure 3.55) and the long Upper Campanian section. The third part is the Studland Bay section from Handfast Point to Studland, which exposes the Studland Chalk and the overlying Palaeogene deposits.

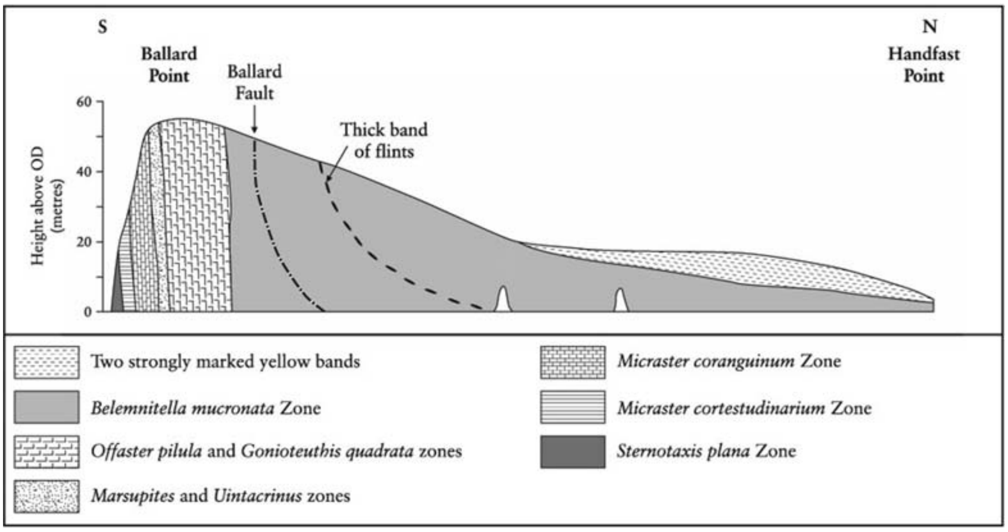

Figure 3.55: Cliff section from Ballard Point to Handfast Point, Isle of Purbeck, Dorset. (After Rowe, 1901, fig. 2.)

Description

The most conspicuous feature of this site is the great Ballard Fault, south of which the Chalk dips are nearly vertical. North of the fault, the beds dip more gently to the north, with the dip becoming 10° north at Handfast Point (Figures 3.55 and 3.56). Each layer is brought to sea level in turn by the dip. This dip creates a 2500 m long section in the *B. mucronata* Zone, which Rowe estimated to be here about 76 m thick.

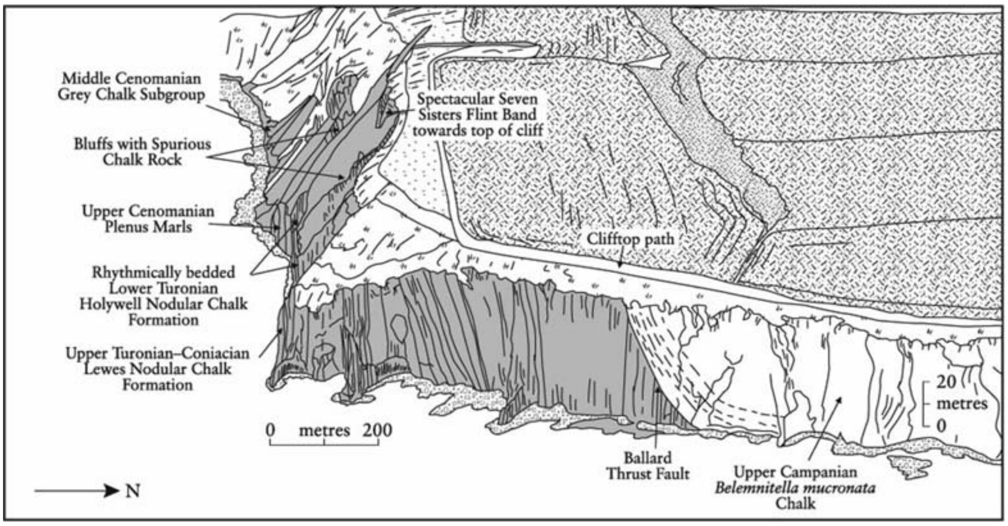

Figure 3.56: Chalk stratigraphy and the major thrust fault in the Chalk at Ballard Point, Dorset (see Figure 3.54a).

The curving plane of the thrust fault (Rowe, 1901, p. 35, pl. VIII) is located low in the Portsdown Chalk Formation, along a marl seam that, on photographic evidence, can be inferred to be the Shide Marl (see the Whitecliff GCR site report, this volume), not far above the base of the *mucronata* Zone. On the north side of the Handfast Point to Ballard Point headland is Studland Bay, where well-developed dissolution pipes into the Chalk are found below the Chalk–Palaeogene contact. Studland Bay is also the type locality for the Studland Chalk Member (Gale *et al*., 1988).

Barrois (1876) was once again the first to provide an account of these cliff sections. He identified the great Ballard Fault and the *B. mucronata* Zone beneath the fault.

Strahan's memoir for the Isle of Purbeck (1898) included a description of the Ballard Fault, but it was Rowe (1901) who provided the first fully detailed and comprehensive account of the 'zonal' stratigraphy. The [British] Geological Survey (Jukes-Browne and Hill, 1904) largely followed the observations of Barrois, Strahan and Rowe. Others have reviewed these sections (Wright, 1947) but in less detail. Later research concentrated on particular parts of the stratigraphy or structure. Drummond (1967, 1970) investigated the Albian–Cenomanian deposits in Punfield Cove. Gale (1995, fig. 12) illustrated the cyclostratigraphy of part of the Zig Zag Chalk Formation. Although the Plenus Marls Member, at the base of the White Chalk Subgroup, is well exposed, this was not a site visited by Jefferies (1962, 1963). A log of the member was given by Gale (1995, fig. 14).

Gale (1996, p. 178) introduced the term 'Ballard Cliff Member' (named after this site) for the basal beds of the Holywell Nodular Chalk Formation overlying the Plenus Marls Member. His member extends up to the top of the Meads Marls and hence includes the Melbourn Rock–Meads Marls as defined by Mortimore (1986a) in Sussex. He also provided (Gale, 1996, fig. 5) a log of the New Pit Chalk Formation and the basal Lewes Nodular Chalk Formation (including the Spurious Chalk Rock) up to Southerham Marl 1. The Holywell Nodular Chalk to Seaford Chalk sections were investigated by Mortimore and Pomerol (1987, figs 8, 9) and the highest Studland Chalk by Gale *et al*. (1988).

Strahan (1898) discussed the slickensided structure of much of the chalk adjacent to the Ballard Fault. The Ballard Fault was illustrated photographically by Ameen (1990, fig. 3). Conflicting models for the generation of the fault were reviewed by Carter (1992) and by Ameen and Cosgrove (1992). Ameen and Cosgrove (1990) investigated the detailed fracture pattern in the Chalk at Studland Bay to determine the post-Mesozoic stress history of the Chalk (see also Carter, 1992). Barrois (1876) thought that the *Marsupites* Zone occupied all the section stratigraphically above the fault. This was corrected by Rowe (1901), who realized that the fault occurred within, but close to the base of, the *B. mucronata* Zone.

Upper Greensand–Grey Chalk Subgroup

Drummond (1967) described the Albian–Cenomanian Upper Greensand–Lower Chalk section in Punfield Cove just west of Ballard Point. He separated the Upper Greensand into two beds. The lower bed, nearly 1 m thick, consists of nodular, coarse greensand passing down into soft, coarse greensand. This is overlain by the second bed, a 0.2–0.3 m thick layer of bored limestone doggers. These two beds lie beneath an erosion surface on which is the 0.3–0.4 m thick Basement Bed, a condensed, nodular glauconitic sandstone of greensand pebbles in a Glauconitic Marl matrix forming the basal unit of the Glauconitic Marl. This is overlain by 0.6 m of calcareous sandstone with both phosphatized and unphosphatized fossils. There is a further 0.6 m of Glauconitic Marl with unphosphatized fossils.

The Glauconitic Marl grades up into about 10 m of marly chalk separated by an erosion surface from a further 3 m of glauconitic, marly chalk. The overlying 27 m of Zig Zag Chalk Formation is massively bedded and contains thin marl seams.

White Chalk Subgroup

The Plenus Marls Member at the base of the Holywell Nodular Chalk Formation is well developed and all of Jefferies' (1962, 1963) numbered beds can be identified. Beyond the Plenus Marls, which are still accessible on the beach, the section becomes increasingly hazardous. The lower part of the Holywell Nodular Chalk, with a weakly developed Melbourn Rock (in the sense of Sussex, Mortimore, 1986a) at the base, is washed clean on the last part of the beach area, but the beds above are exposed in precipitous, loose, cliff faces. Fallen blocks of Holywell Nodular Chalk yield abundant shell-debris layers, as well as the typical flaser marl seams and intraclast beds. Rowe (1901, p. 40) noted a flint band at the boundary between the *Rhynchonella* (i.e. *Orbirhynchia*) *cuvieri* and *Terebratulina gracilis* (i.e. *lata*) zones, which corresponds to a level around the Glyndebourne Flints and the Gun Gardens Main Marl (Mortimore and Pomerol, 1996). This flint is shown at the base of the section in Gale (1996, fig. 5).

Rowe (1901), by landing from a boat, found a magnificent, clean, air-weathered section in the *Terebratulina gracilis* (*lata*) Zone just south of Ballard Point. He noted the absence of flint, and also observed marl seams that did not weather back into grooves (probably the brittle marls such as New Pit Marls 1 and 2). Rowe also noted the yellow-green nodule beds of the Spurious Chalk Rock well within the *Terebratulina gracilis* (*lata*) Zone. The same Spurious Chalk Rock horizons are to be found in the high bluffs on the cliff face (Mortimore and Pomerol, 1987, fig. 9). Many of the fallen blocks at beach level also contain the glauconitic surfaces of the Spurious Chalk Rock hardgrounds.

Mortimore and Pomerol (1987, fig. 9) published a section logged in the chalk bluffs high in the dangerous cliff, showing the position of the Spurious Chalk Rock in relation to the marker marl seams in the lower Lewes Nodular Chalk Formation. The Southerham, Caburn and Bridgewick marl seams are well developed. The Lewes Tubular Flints are also spectacularly developed in tough, red, iron-stained and very grey, nodular chalks. There are many fallen blocks of chalk from this horizon at beach level. Each of the marker beds in the upper Lewes Nodular Chalk has been identified, including the Cuilfail Zoophycos Beds, Navigation Marls and the Cliffe Hardground.

Exposures in the Seaford Chalk Formation are limited. However, the Seven Sisters Flint Band, associated with conspicuous large potstones can be examined high in the cliff close to the cliff-top path. Strahan (1898), Rowe (1901) and Jukes-Browne and Hill (1904) all provided a longitudinal section of the cliff from Ballard Point northwards to Handfast Point (Figure 3.55). Their sections showed the traditional zones of the Chalk, but these can be used to identify the lithostratigraphy. The *Micraster coranguinum* Zone broadly corresponds to the Seaford Chalk Formation, while the *Uintacrinus socialis*, *Marsupites testudinarius* and *Offaster pilula* zones broadly conform to the Newhaven Chalk Formation. It is inferred that the crinoid and *O. pilula* zones contain marl seams here, as these are present at Scratchell's Bay, Isle of Wight, to the east, and at Arish Mell, Bats Head and Middle Bottom near **White Nothe** to the west (see GCR site report, this volume). This is supported by the fact that Rowe (1901) indicated that these beds were conspicuous because of the reduced amount of flint; and that his broadly conceived *Actinocamax quadratus* Zone (which included the *Offaster pilula* Zone) was marly with discrete veins.

The very large columnar flints noted by Rowe (1901, p. 35) south of the Ballard Fault are probably in the upper part of the *Gonioteuthis quadrata* Zone. It is possible that these correlate with the Warren Farm Paramoudra Flints in the Culver Chalk Formation of Portsdown and Culver Cliff, Isle of Wight (see Figure 3.15; and the Whitecliff and Downend Chalk Pit GCR site reports, this volume). The overlying beds belong to the basal Portsdown Chalk Formation.

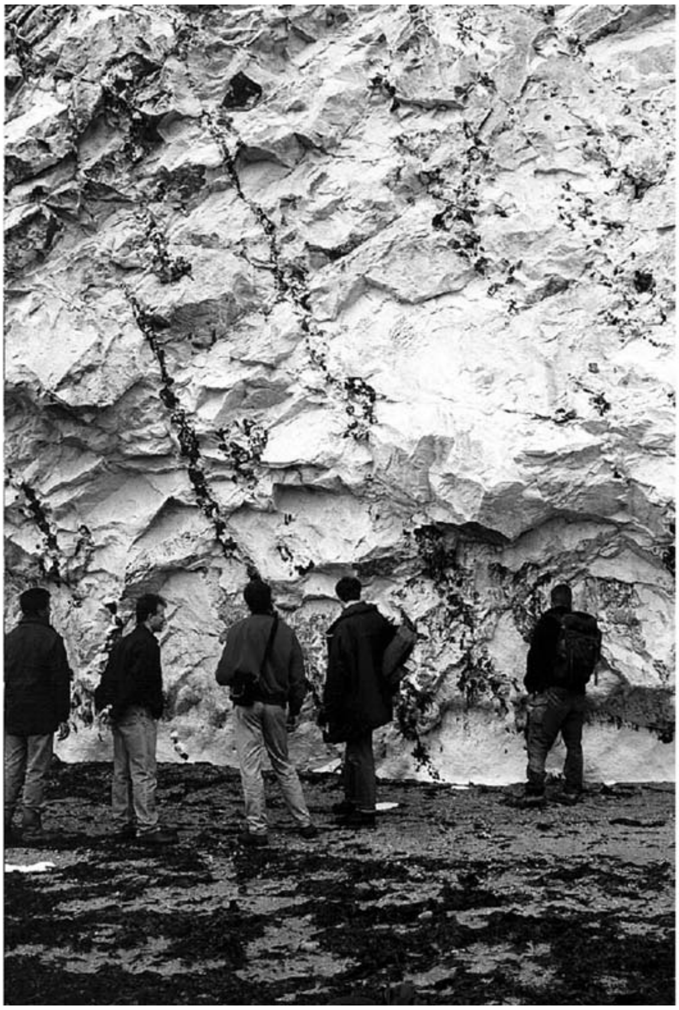

Figure 3.15: (a) Large Paramoudra flints (P) from the Warren Farm Paramoudra horizon, Whitecliff, Isle of Wight. (b) Large Paramoudra flint fallen to the beach, Whitecliff, Isle of Wight. (Photos: R.N. Mortimore.)

Rowe noted some bands of very large flints in the beds north of the fault. One of his strong flint bands, *c*. 30 m above the fault plane, was used by him as a marker, noting that it came to the shoreline 30 m north of the first pinnacle. At the top of the cliff, above this point, Rowe identified two well-developed yellow, nodular chalk bands, *c.* 30 m above the flint. These he traced to Handfast Point and Old Harry where they were about two-fifths of the way up the cliff, coming to beach level in Studland Bay west of Handfast Point. The upper of these bands is the weaker and dies out northwards. Gale *et al.* (1988) took the upper band as the basal marker of their Studland Chalk (Member).

Cenomanian Stage

The calcareous sandstone in the lower part of the Glauconitic Marl resting on the Basement Bed, contains phosphatized internal moulds of ammonites (*Turrilites costatus* Lamarck and *Schloenbachia*) derived from the *T. costatus* Subzone of the *Acanthoceras rhotomagense* Zone, and sporadic unphosphatized specimens of the brachiopod *Dereta pectita* (J. Sowerby). From the overlying sandy Glauconitic Marl unphosphatized brachiopods (*Orbirhynchia mantelliana* (J. de C. Sowerby), *Grasirhynchia grasiana* (d'Orbigny) and *Concinnithyris subundata* (J. Sowerby)) have been collected. The *Orbirhynchia* point to a correlation with the *Orbirhynchia mantelliana* Band near the top of the *costatus* Subzone in basinal sections. This Middle Cenomanian assemblage, both reworked and indigenous, correlates with that of the expanded sections at **Southerham Grey Pit** (see GCR site report, this volume), which are developed in rhythmically bedded marly chalk facies.

Holaster subglobosus (Leske), *Camerogalerus cylindricus* (Lamarck) and *Concinnithyris subundata* occur in the marly chalk above the Glauconitic Marl, indicating the *Turrilites acutus* Subzone of the *Acanthoceras rhotomagense* Zone. Within the Zig Zag Chalk Formation, *Acanthoceras jukesbrownei* (Spath) is common in Jukes-Browne Bed 7, and Wright (1947) recorded *Calycoceras* from Punfield Cove. Bands of *Holaster* are a feature of the Zig Zag Chalk Formation here.

The belemnite *Praeactinocamax plenus* (Blainville) is present in the Plenus Marls Member (Wright, 1947, p. 199). Bands full of *Inoceramus pictus* J. de C. Sowerby were found in both the Plenus Marls and basal Holywell Nodular Chalk in a section on Ballard Down. One specimen of the zonal index ammonite *Metoicoceras geslinianum* (d'Orbigny) was also found in the basal beds of the Plenus Marls at the same locality.

Turonian Stage

A standard succession of *Mytiloides* shell-beds in the Lower Turonian Holywell Nodular Chalk Formation can be pieced together from the fallen blocks towards Ballard Point. The band of flints identified by Rowe is presumed to correlate with the Glyndebourne Flints because one block contained both these flints and the overlying beds with *M. subhercynicus* (Seitz). Rowe (1901, p. 33) found an air-weathered section in the Middle Turonian New Pit Chalk Formation, which yielded a diverse collection of fossil echinoids and brachiopods.

Fallen blocks of Upper Turonian chalk belonging to the Lewes Nodular Chalk Formation at the horizon of the Lewes Tubular Flints contain abundant regular echinoids (*Gautheria radiata* (Sorignet)), a feature not seen in more basinal successions in Sussex and Kent.

Coniacian to Campanian stages

As Rowe (1901) noted, collecting from the chalk between Ballard Point and Handfast Point is both hazardous and almost impossible because of the very hard chalks and the seaweed cover at the base of the cliffs. He established the position of the Upper Santonian *Uintacrinus socialis* and *Marsupites testudinarius* zones but could not find the Lower Campanian *Offaster* (his *Cardiaster*) *pilula* beds. Unfortunately, Brydone never managed to include this section in his review of the *Offaster pilula* Zone. Worn and battered belemnites provided Rowe with the evidence for the *Gonioteuthis quadrata* and *Belemnitella mucronata* zones. Rowe (1901) devoted several pages to a discussion of the fossils in the *B. mucronata* Zone of Dorset, including those of this site. In particular, he recorded conical forms of *Echinocorys* (i.e. presumably *Echinocorys conica* (Agassiz) and related forms) in a band north and south of the southernmost pinnacle. In addition, Rowe noted the entry of the small brachiopod *Magas pumilus* J. Sowerby (i.e. *M. chitoniformis* (Schlotheim)) in the *mucronata* Zone towards Old Harry and in Studland Bay, at about the level of the two yellow-nodular beds marking the base of the Studland Chalk Member of Gale *et al.* (1988).

Interpretation

Access to much of the section between Ballard Point and Handfast Point is very limited and consequently a detailed stratigraphy has not been established. Vital evidence for the Late Cretaceous overstep, however, is provided by the Albian–Cenomanian section exposed in Punfield Cove just west of Ballard Point. In conjunction with the **Compton Bay** and **White Nothe** GCR sites, the Punfield section is critical to a study of the great Late Cretaceous transgression in the region, as illustrated by Drummond (1967, 1970).

Rowe (1901) used the occurrence of a small *Echinocorys* (presumably *Echinocorys subconicula* Brydone) in the cave at the base of the thrust plane to identify a position close to the base of the *mucronata* Zone. Photographs of the section enabled Professor A.S. Gale (pers. comm., 1999) to recognize the same marl seams as are seen in the sections at the **Whitecliff** GCR site, and Scratchell's Bay on the Isle of Wight. These photographs show that the Ballard Fault slices through these beds along the Shide Marl, which is situated only a short distance above the Farlington Marls at the base of the zone, thus confirming Rowe's interpretation.

The entry of the brachiopod *M. chitoniformis* is an important bio-event in the lower part of the *mucronata* Zone of the Southern Province and Norfolk sections, a fact that was recognized by both Rowe and Brydone. For example, the absence of this species from the highest *mucronata* Zone sections on Portsdown shows that only the basal part of the zone (pre-Weybourne Chalk of Wood (1988)) is represented there, whereas the sections in the present site, in inland Dorset and on the Isle of Wight, extend up into the equivalent of the Weybourne Chalk of Norfolk (see Figure 4.5, Chapter 4).

Stage		Southern England	Norfolk (Peake and Hancock, 1961, 1970)	Belemnites	Echinoids	Norfolk (Johansen and Surlyk, 1990)	Norfolk (Christensen, 1995, 1999)	
Maastrichtian	Upper	Not represented	Not represented	*Belemnella kazimirovensis*	Not represented		Not represented	*Belemnella*
				Belemnitella junior				
	Lower		Grey Beds	*Belemnella licharewi*	*Echinocorys* aff. *limburgica*	Beacon Hill Grey Chalk		*Belemnella sumensis*
			White Chalk with *O. lunata*		*Echinocorys ciplyensis*	Little Marl Point Chalk Member		
			Sponge Beds			Trimingham Sponge Beds Member		
			Porosphaera Beds	*Belemnella lanceolata*	*Echinocorys belgica*	Sidestrand Chalk Member	*Belemnitella minor* II [*minor* III]	*Belemnella obtusa*
			Sidestrand Chalk		*Echinocorys* passage forms			*B. pseudobtusa*
Campanian	Upper		Paramoudra Chalk	*Belemnitella langei* dominant	*Echinocorys pyramidata* Portlock	Paramoudra Chalk Member	*Belemnitella minor* II	*B. lanceolata*
					?			
			Beeston Chalk		*Echinocorys conoidea* *Galerites roemeri-abbreviatus*	Beeston Chalk Member	*Belemnitella minor* I	
					Echinocorys aff. *conoidea* *Cardiotaxis ananchytis*			
			Catton Sponge Bed	*Belemnitella mucronata minor* and allied forms common	*Echinocorys ovata* auctt.	Catton Sponge Bed		
			Weybourne Chalk		*Echinocorys gibba* *M. stolleyi*	Weybourne Chalk Member	*Belemnitella woodi*	
		Highest Chalk Isle of Wight and Dorset	Pre-Weybourne Chalk [Eaton Chalk]		*Echinocorys subglobosa fonticola*	Eaton Chalk Member	*Belemnitella mucronata* sensu stricto	
				Belemnitella mucronata sensu stricto	*Echinocorys subglobosa* *C. heberti*			
		Belemnitella mucronata Zone			*Echinocorys pyramidata* auctt. var. *quenstedi*			
					Echinocorys marginata approaching *subglobosa*			
		Base of Zone in Hampshire	Pre-Weybourne Chalk [Basal Mucronata Chalk]		*Echinocorys lamberti*			
		-------(2)-------			*Echinocorys lata fastigata*			
	Lower (pars.)	*Gonioteuthis quadrata* Zone	*Gonioteuthis* Zone	*Gonioteuthis quadrata*	?			

Figure 4.5: The 'high' Chalk of Norwich and north Norfolk based on Peake and Hancock (1961, 1970); Wood (1988); Johansen and Surlyk (1990); and Christensen (1995, 1999).

Gale (1996, fig. 5) showed that eight more marl–chalk couplets of the New Pit Chalk Formation were preserved here beneath the base of the Spurious Chalk Rock (Ogbourne Hardground of the standard Chalk Rock stratigraphy) than at the **Compton Bay** GCR site.

Conclusions

There are four key aspects to the Handfast Point to Ballard Point section. The first is seen at Punfield Cove where the West Melbury Marly Chalk Formation of Central Dorset and elsewhere in the Southern Province is absent, being represented only by *remanié* phosphatized internal moulds of Middle Cenomanian fossils in the glauconitic Basement Bed at the base of the Zig Zag Chalk Formation. This relates to the regional Cretaceous overstep that progressively develops westwards and to the local tectonic control of sedimentation with uplift along the Purbeck–Wight Fault. The second is the remarkable abundance of regular echinoids in the interval containing the Lewes Tubular Flints, which again is related to the palaeogeographical position of the site in the Upper Turonian along the line of a fault-controlled shelf. The third relates to the spectacular Ballard Fault that brings the folded basal*Belemnitella mucronata* Zone (Portsdown Chalk Formation) into juxtaposition with vertical beds low in the same formation. The tectonic complexity of this remarkable structure and its initiation remain points of continuing controversy. The fourth aspect is the exposure of the longest continuous sections in the *mucronata* Zone in the Southern Province. In addition there are invaluable data from the near-horizontal Upper Campanian strata in Studland Bay, making this complete coastal section critical to Upper Cretaceous studies.

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